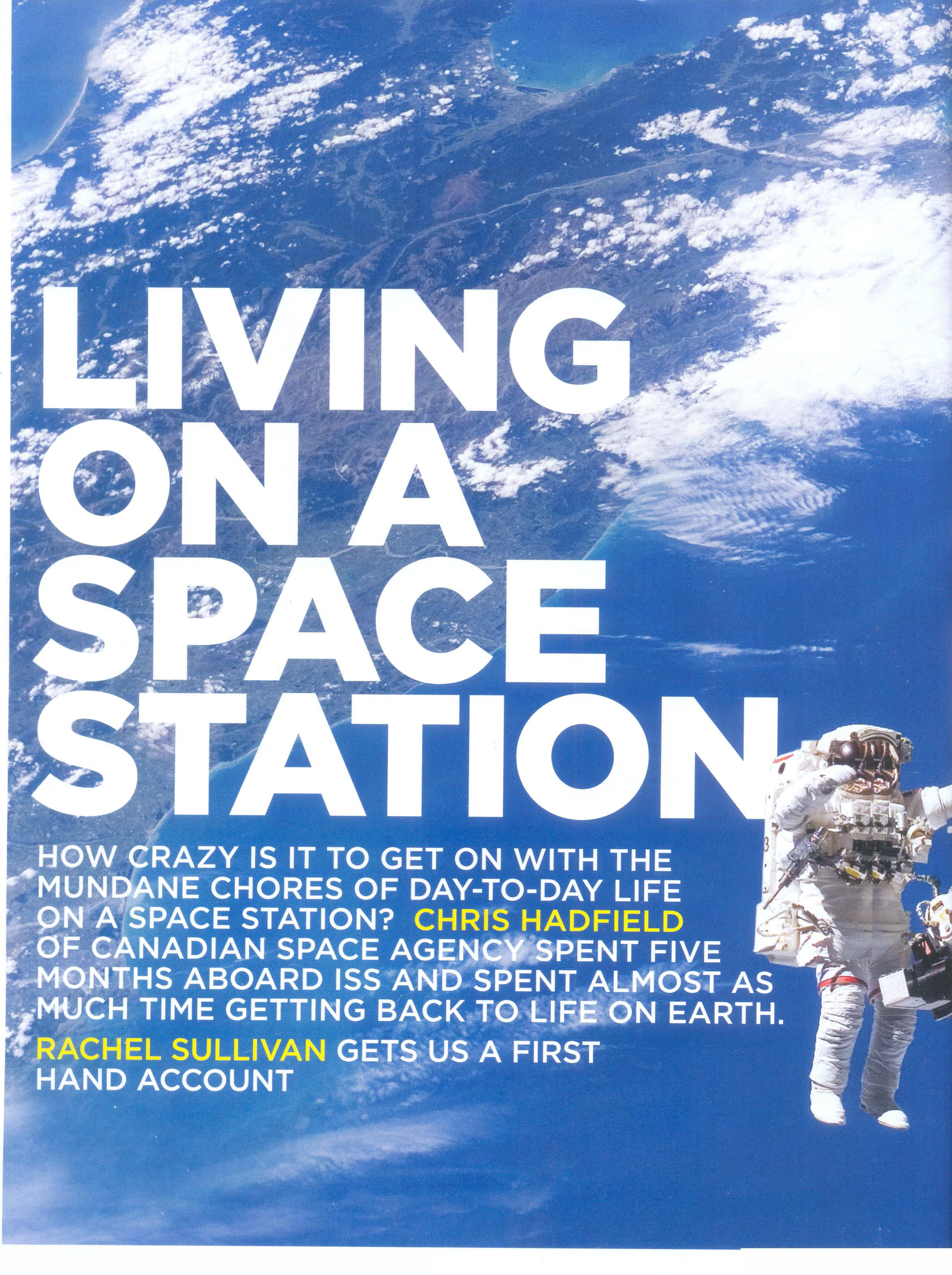
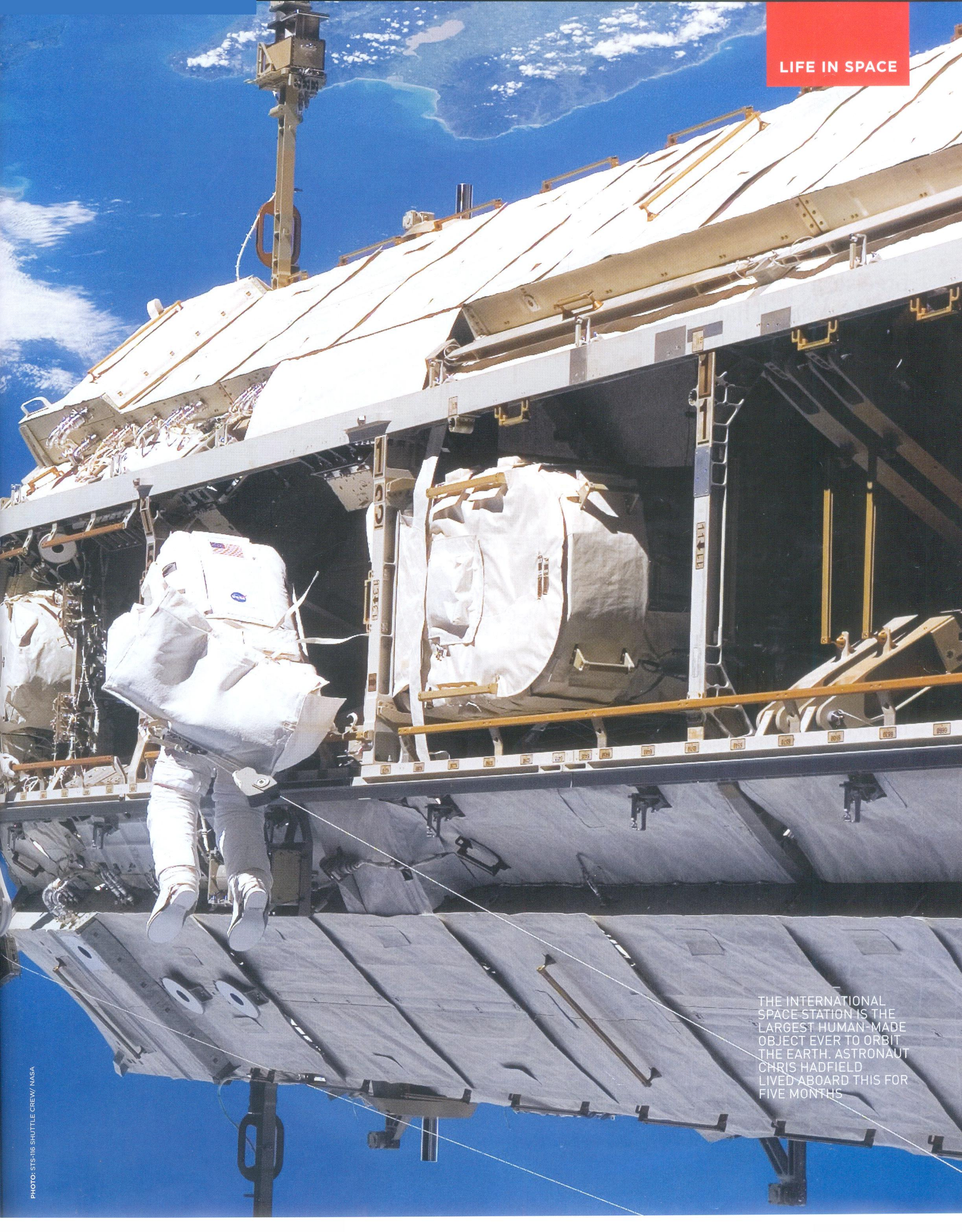


LIVING ON A SPACE STATION

HOW CRAZY IS IT TO GET ON WITH THE MUNDANE CHORES OF DAY-TO-DAY LIFE ON A SPACE STATION? **CHRIS HADFIELD** OF CANADIAN SPACE AGENCY SPENT FIVE MONTHS ABOARD ISS AND SPENT ALMOST AS MUCH TIME GETTING BACK TO LIFE ON EARTH.

RACHEL SULLIVAN GETS US A FIRST HAND ACCOUNT



THE INTERNATIONAL SPACE STATION IS THE LARGEST HUMAN-MADE OBJECT EVER TO ORBIT THE EARTH. ASTRONAUT CHRIS HADFIELD LIVED ABOARD THIS FOR FIVE MONTHS

PHOTO: STS-116 SHUTTLE CREW/ NASA

[redacted]

Every movement is controlled and precise, a zero gravity version of *tai chi*. A small hatch opens very slowly as a single figure, Chris Hadfield, eases himself out in measured movement from the round aperture. Leaving the hatch, and holding onto the space station by a single hand, all movement ceases, except that of Earth, spinning past the spaceman at eight kilometres per second, 250 kilometres below.

"It is an incredible and inexpressible feeling," he says, describing his first spacewalk from the International Space Station (ISS), in 2013. "To be suspended between our world and the universe alone — a phenomenally humbling experience that is also utterly magnificent. Everything pales compared with floating weightless in the universe," he recalls.

FLIGHT ENGINEER CHRIS HADFIELD OF THE CANADIAN SPACE AGENCY CONDUCTS A "FIT CHECK" DRESS REHEARSAL INSIDE THE SOYUZ TMA-07M SPACECRAFT IN 2012

PHOTO: NASA

Recently retired, Hadfield is one of the most famous astronauts in the world right now. A member of the Canadian Space Agency (CSA), he was commander of the International Space Station (ISS) in 2013, the highlight of a long and illustrious career as an astronaut, which came at a time when interest in the space station had never been higher.

Until recently, what has happened in space, has tended to stay in space. But this time was different. While onboard the ISS, Hadfield found fame thanks to an engaging series of YouTube video clips, which helped to demonstrate how, when released from the confines of gravity, even the most everyday tasks soon becomes compelling viewing. Among dozens of other insights into daily life in space, millions of viewers watched Hadfield cut his nails (over an air vent to stop the stray clippings being later inhaled), and demonstrated that water wrung out of a towel clings to the user's hands. And, memorably, he helped prove that in space, tears don't fall — they pool in an ever expanding jellyfish-like blob.

For the space worker, these were the geeky intrigues of life in space that just needed sharing. "I just thought if I found those things really neat, others might too," he tells *Discovery Channel Magazine* over the phone from his home in Canada.

Hadfield's compelling online commentary about life in space then reached its crescendo, with his charming rendition of David Bowie's astro-inspired song, *Space Oddity*. It was appropriately filmed, as Bowie famously observed in the song, while Hadfield was still "floating in a most peculiar way", suspended high above our mortal coil, strumming his beloved Yamaha FG 18 guitar, the same instrument he had in tow while hitch-hiking through Europe as a 17-year-old.

The clip was released on YouTube the evening before he was due to part ways with the ISS, in May 2013. By the time his Soyuz craft had touched down in Kazakhstan a few hours later, the song, featuring Hadfield's distinctively non rock and roll voice, had already been downloaded seven million times — a figure that has since tripled and is close to quadrupling. Not only did it help make a classic space-inspired song relevant again to a new generation, but ▸

A WALK THROUGH **THE SPACE STATION**

ISS CONFIGURATION

🟥 RUSSIA
- ① ZVEDA SERVICE MODULE
- ② MULTIPURPOSE LABORATORY MODULE
- ③ ZARYA CONTROL MODULE
- ④ DOCKING PORT

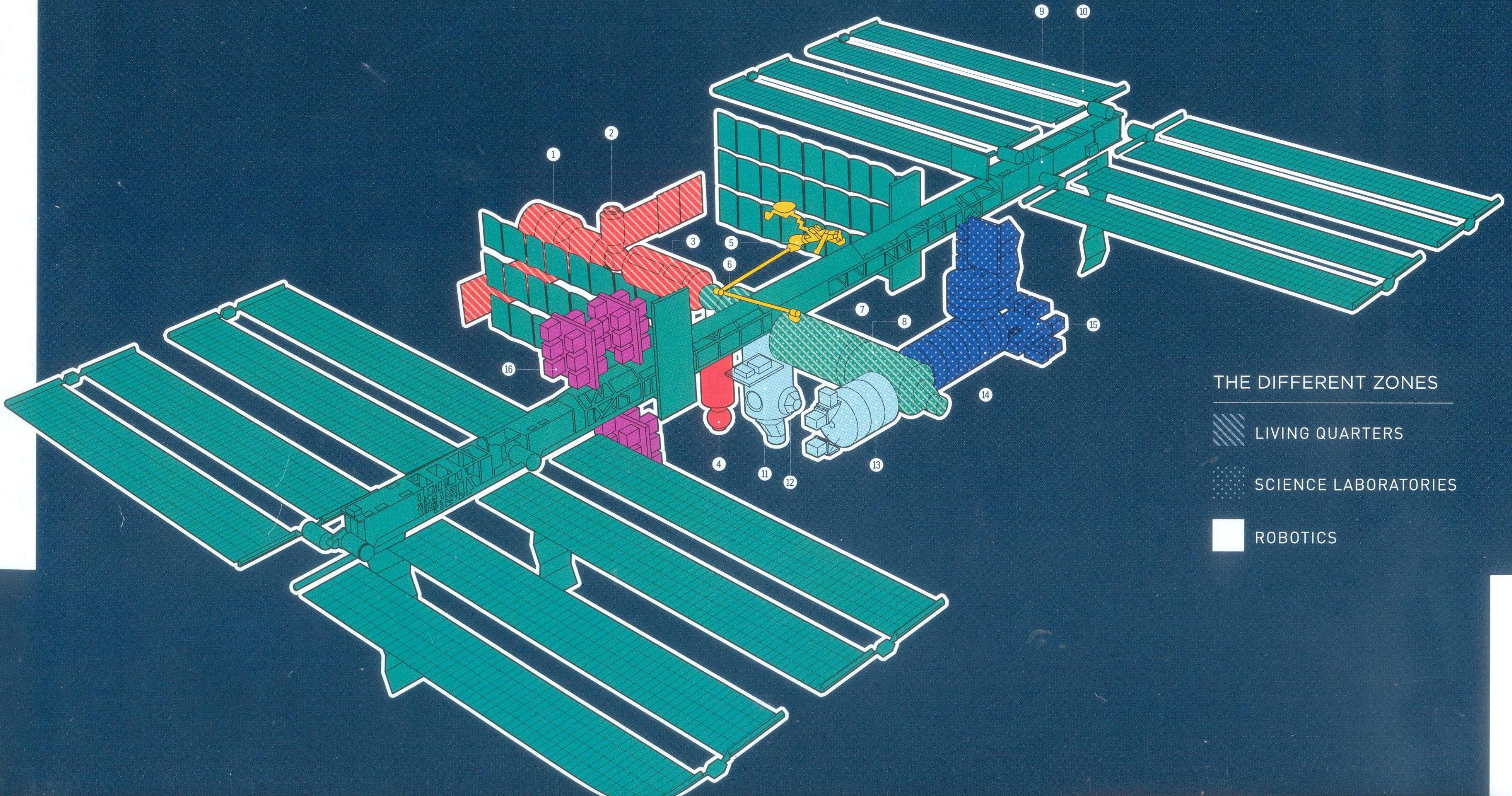
🟨 CANADA
- ⑤ CANADAARM2 MOBILE SERVICING MODULE

🟦 EUROPEAN MODULES (ESA)
- ⑪ TRANQUILITY MODULE
- ⑫ CUPOLA
- ⑬ COLOMBUS LABORATORY

🟩 AMERICA
- ⑥ UNITY MODULE
- ⑦ DESTINY LABORATORY
- ⑧ HARMONY NODE
- ⑨ STRUCTURE
- ⑩ SOLAR PANELS

🟦 JAPANESE MODULES
- ⑭ KIBO RESEARCH MODULE
- ⑮ KIBO OUTER RESEARCH PLATFORM

🟪 BRAZIL MODULES
- ⑯ EXPRESS PALLET

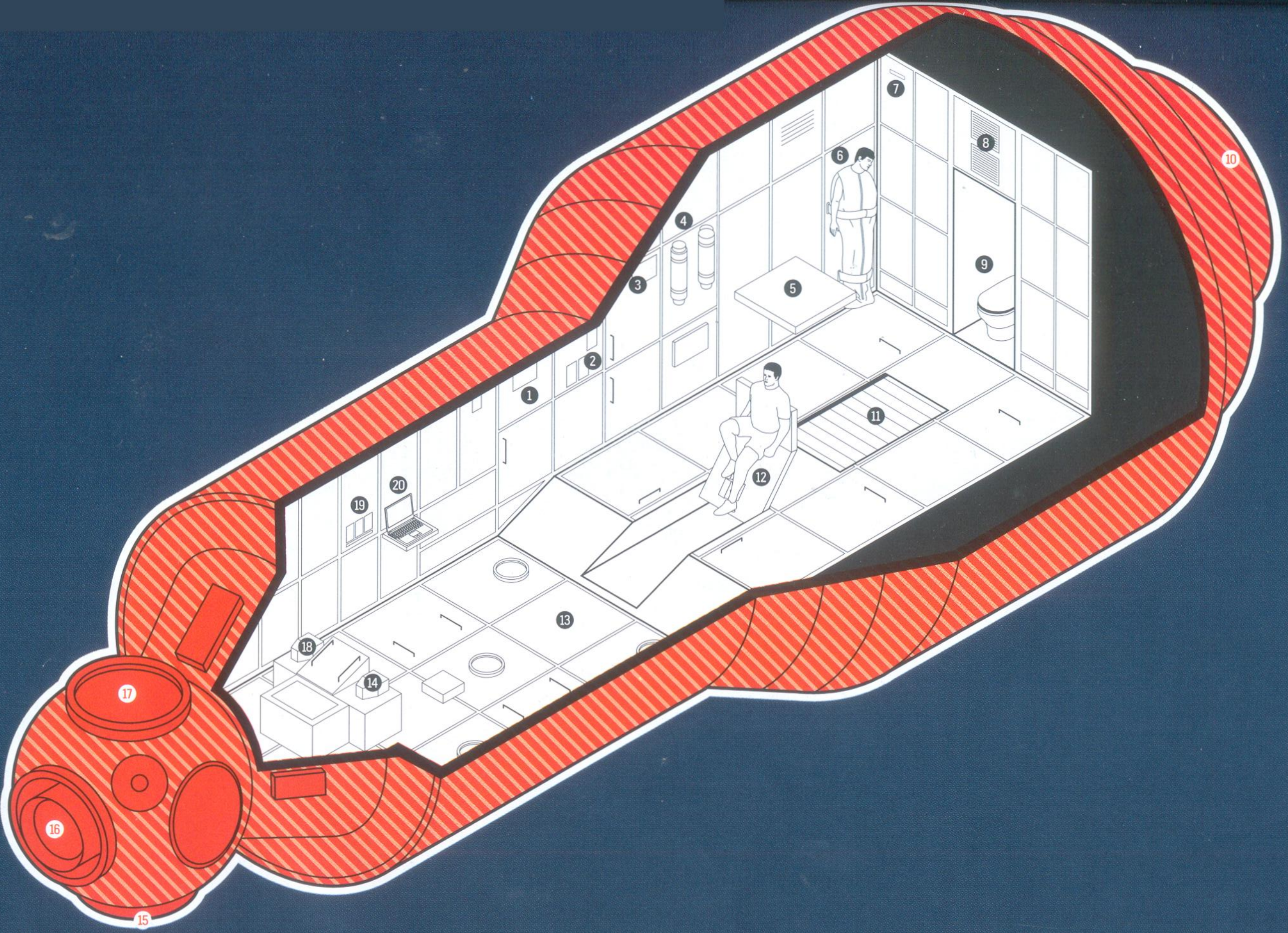


THE DIFFERENT ZONES

- ▨ LIVING QUARTERS
- ░ SCIENCE LABORATORIES
- ⬜ ROBOTICS

ZVEDA SERVICE MODULE

1. INTEGRATED CONTROL PANEL
2. LIGHTING CONTROL PANEL
3. VONZDUKH CONTROL PANEL
4. SOLID FUEL OXYGEN GENERATORS (SFOG)
5. GALLEY TABLE
6. CREW SLEEP COMPARTMENT
7. CAMERA
8. AIRFLOW VENT
9. WASTE MANAGEMENT COMPARTMENT
10. SOYUZ AND PROGRESS DOCKING PORT
11. TREADMILL AND VIBRATION ISOLATION SYSTEM
12. VELA ERGOMETRE
13. BODY MASS MEASUREMENT
14. CAUTION AND WARNING PANEL, CLOCK AND MONITORS
15. NADIR DOCKING PORT
16. FORWARD DOCKING PORT
17. ZENITH DOCKING PORT
18. VENTILATION SCREEN
19. COMMUNICATIONS PANEL
20. TORU RENDEZVOUS CONTROL STATION



ISS TRANSPORTATION VEHICLES

P CREW C CARGO

P C

SPACE SHUTTLE

Lifetime:
133 successful launches; two failed launches
Status:
Retired; July 21, 2011
First Orbital Launch:
Columbia;
April 12, 1981

P

SOYUZ

Lifetime:
Up to six months docked to station;
Status:
In service, one is onboard the ISS at all times
First Manned Launch:
April 23, 1967

C

PROGRESS

Lifetime:
Unmanned resupply freighter with 3 or 4 flights per year
Status:
In service
First Launch:
January 20, 1978

C

AUTOMATED TRANSFER VEHICLE (ATV)

Lifetime:
Carries both bulk liquids and relatively fragile freight
Status:
In service, but closing in 2015
First Launch:
March 9, 2008

C

H-II TRANSFER VEHICLE (HTV)

Lifetime:
Unmanned cargo spacecraft, aka Kounotori, the "White Stork"
Status:
In service
First Launch:
September 10, 2009

C

DRAGON

Lifetime:
First commercially built and operated spacecraft; can be manned or robot-operated
Status:
In service
First Launch:
December 8, 2010

C

CYGNUS

Lifetime:
Unmanned resupply spacecraft; can last up to one week to two years
Status:
In service
First Launch:
September 18, 2013

the whirlwind of media that followed him also created global interest, not just in Hadfield, but in the space programme too.

HOT ROCKETS

By any measure, space has been big news in recent times. As the *Curiosity Rover* continues to beam back intriguing images from its ongoing search for signs of life on Mars, plans are being fast-tracked to establish a human settlement on the Red Planet. Despite the risks, there have been no shortage of people eager to follow in Curiosity's tracks: when private organisation *Mars One* called for volunteers to make the one-way trip to the colony that it plans to establish in 2023, more than 200,000 people applied. While NASA has publicly said little so far about the *Mars One* venture, the space agency also has its own plans to send astronauts to Mars within the next 20 years. In the meantime, the ISS has a lot more to teach people about the challenges of living in space.

Arguably humankind's greatest technical achievement, the US $100 billion outpost has been operational for

> MOISTURE'S STRANGE BEHAVIOUR IN THE ABSENCE OF SURFACE TENSION MEANS **THAT BACTERIAL AND MOULD GROWTH BECOMES A CONSTANT ISSUE.**

BUGGING OUT

It's an arachnophobe's delight in space — there are no creepy crawlies. "On the ISS you see little particles of dust that your mind automatically identifies as insects," Hadfield says. "But there are zero insects which is a really strange feeling, because insects like ants are perfectly designed for life without gravity." There are some insect experiments planned in the near future. "Small animals that reproduce quickly allow scientists to measure how balance and other things are affected in multiple generations. It's a good place to predict the effect on humans."

"FAR ABOVE THE WORLD, PLANET EARTH IS BLUE" SANG DAVIE BOWIE IN HIS 1969 HIT *SPACE ODDITY*. OVER 44 YEARS LATER, ASTRONAUT CHRIS HADFIELD'S YOUTUBE VIDEO VERSION (RIGHT) OF THE SONG HAS GARNERED OVER 22 MILLION HITS

PHOTOS: USGS EROS DATA CENTER (RICHAT STRUCTURE); NASA (CHRIS HADFIELD)

15 years and continuously populated since November 2000. Hurtling through space at more than 28,000 kilometres per hour, it is maintained by a rotating crew of six astronauts and cosmonauts from the US, Russia, Europe, Canada and Japan. Four times the size of the now-defunct Soviet and Russian space station Mir, which operated from 1986 to 2001, the ISS — at 109 metres in length — is the largest space lab ever built, and although almost weightless in space, its mass is impressive, at around 420 tons.

Yet despite the cutting edge technology that has gone into its creation, life "on station" constantly throws up curious new challenges. Moisture's strange behaviour in the absence of surface tension means that bacterial and mould growth becomes a constant issue. Flames burn spherically. And then there is 'stiction', a term that astronauts have coined to describe the way fragile materials stick together when there is no gravity to pull them apart.

Dust, skin and other detritus shed by astronauts doesn't simply fall to the floor – instead it floats around until being sucked into an air filter, or inhaled. Needless to say, space station residents devote considerable time each day to mundane cleaning chores, and a considerable amount of time to tracking down wayward objects. Different nationalities come up with different living solutions. "The Russians wallpaper the walls with Velcro," Hadfield notes. "In the US section, they're concerned about the flammability of having too much cloth around, so there's a limited amount of Velcro. But it's still incredibly useful for keeping things under control."

BEST TRIP AROUND

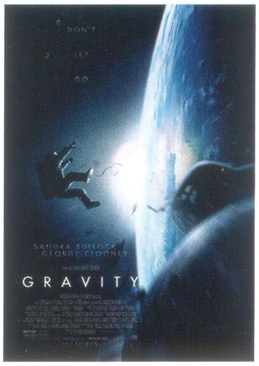
While the trip to the ISS can be made in less than six hours — faster than flying via aeroplane from New York to London — for astronauts like Hadfield getting onto the Space Station is the journey of a lifetime. After blitzing test pilot training in the 1980s, Hadfield was selected by the CSA in 1992. Based at NASA, he oversaw 25 Shuttle launches and directed operations of Russia's Star City. He was also chief of robotics at NASA and chief of International Space Station operations prior to his mission as Commander of the ISS.

In between roles, he commanded NEEMO 14, a NASA undersea mission to simulate exploration missions to the surface of asteroids, moons and Mars in order to gain a better understanding of how astronaut crews interact with equipment including advanced spacesuits, a lander, a rover and robotic arms.

In Canada's Pavilion Lake, he was also part of a team to study microbialites, structures formed by aquatic micro-organisms that were very common for about two billion years of Earth's early history. The Pavilion Lake microbialites provide insight into the biogeochemical processes that were active on our young planet, and potentially on other planets such as Mars.

While undersea missions

GRAVITY FACT CHECK



Moviegoers held their breath when medical engineer Ryan Stone (Sandra Bullock) made her maiden voyage to space with veteran astronaut Matt Kowalsky (George Clooney) in the 2013 sci-fi hit film *Gravity*. Disaster strikes when they are hit by debris from an exploding satellite, with no way home, and oxygen running out rapidly. The film has been praised for its accurate portrayal of life in space, winning seven Oscars including Best Cinematography and Best Visual Effects. But even so, the filmmakers had to take some artistic licence.

While being hit by debris is certainly a risk for the space station or for any astronaut on a spacewalk, the debris field depicted in the film would be highly unlikely to take out a communication satellite.

According to former astronaut Garrett Reisman there is no way to go hopping from one spacecraft or space station to another so easily. The Hubble Space Telescope, the International Space Station and China's Tiangong-1 are also far too distant from one another to travel between them and are in different orbits and at different altitudes.

If you want to go somewhere in space, simply pointing your vessel in the right direction isn't enough – it takes careful planning and a lot of energy to get there, and a fire extinguisher and landing jets wouldn't provide enough firepower for the job. Also in space, an object's speed depends on its altitude, with objects orbiting faster at lower altitudes because of the gravitational pull of the earth. This makes travel between objects very difficult because any change in speed causes a change in altitude from that of the object you're trying to reach.

Bodies don't freeze instantly when exposed to space, although their fate may actually be worse. Space is a vacuum with its low pressure forcing air out of the lungs with nothing to breathe in again causing unconsciousness within 12 seconds and then suffocation.

Finally, at the speed George Clooney tumbled past Sandra Bullock's character, she would have been unable to catch him, but once caught, she could have simply pulled him back to the space station by his tether because he was weightless, not requiring any heroic self sacrifice.

▸ may seem a long way from space, Hadfield says that astronauts never stop training and expanding their skillset in a raft of new areas, which will in turn help them in their future work in space. "We think it would be more practical to train astronauts in geological techniques than to ask geologists to become astronauts," he comments. "You travel all around the world together, and training can take place at the bottom of the ocean or on an arctic survival mission."

ONE THING THAT TAKES SOME GETTING USED TO IS DIGESTION. "IF YOU BURP IN SPACE YOU THROW UP INSTEAD." WANT TO KNOW HOW IT FEELS? "TRY TO BURP WHILE STANDING ON YOUR HEAD".

A crew is selected a long time before they fly, and selection is based upon a detailed set of characteristics, he explains. "First, the right people are chosen by the lengthy astronaut selection process, and then a subset of those is chosen. They are not random people flung together." Then once a specific mission has been decided upon, the astronauts move into a high gear towards their date with space — mastering and adapting to the demands of the tasks that they will need to complete while onboard.

One of the main considerations is obviously preparing to work in an entirely different physical state to the one we live in on Earth. "Weightlessness can't be simulated accurately, so once the tasks for a mission have been decided, astronauts spend hundreds of hours practicing tasks in the pool," he says.

This further ensures that they are ready to float into action as soon as they arrive on station. "When I arrived, the place felt very familiar," Hadfield remembers. "I knew the people, understood the work, and it all felt familiar," which he says was a tribute to the accuracy of the simulations he'd worked with back home on Earth.

Despite the sense of familiarity, any journey still involves adjustments. On board the Space Station, the sun rises and sets 16 times a day, meaning that astronauts experience a different cycle of day and night. Hadfield says while this was an odd feeling, it is probably easier to deal with than for people living in polar regions of the globe, who experience prolonged days or nights, depending on the season. However, those onboard do take steps to create a sense of normalcy to daily life on station.

"At bedtime, we turn the lights off, and all goes quiet," he says. "We also have regular rituals such as having breakfast and lunch together. Even so, time passes so quickly that it always seems to be Monday or Friday," he laughs. "Five months went by very quickly."

One thing that takes some getting used to is digestion. "The initial transition is hard," Hadfield recalls. "You can't burp without gravity; if you burp in space, you throw up instead." If you want to know how it feels, he suggests, try to burp while standing on your head.

Relieving yourself also takes practice. "Cues to relieving yourself on Earth are driven by weight, for example, the weight of urine in the bladder. But in space, it's more about pressure. And it takes a week or two to adjust.

PAINS OF RETURNING

Long-duration spaceflight has a considerable impact on astronauts' bodies. Space-related wear and tear can include bone and muscle loss, blurred vision, stuffy sinuses, decreased cardiovascular function and sensory motor performance. The lack of downward force on their bodies means they can also grow up to three percent taller while on station. To minimise these effects, and to reduce their recovery time on Earth (which takes at least a day for every day spent in orbit), astronauts need to do hours of load-bearing exercises each day, in order to maintain muscle tone and bone density.

According to his book, *An Astronaut's Guide to Life on Earth*, after five months on the ISS, readjusting to life on Earth proved surprisingly hard for Hadfield. "After five months in space, my body hadn't just adapted to zero gravity, it had developed a whole new set of habits." Walking on feet grown unaccustomed to bearing weight was almost like walking on hot coals, while sitting was little better. His elongated spine recompressed, causing constant lower back pain, while his heart struggled to pump blood to his head when he stood up, causing ongoing vertigo, nausea and fatigue.

While Hadfield is philosophical about such relative suffering, NASA and the Russian space agency Roscosmos are eager to learn more about the effects of

TOP IF THE ISS WERE A SCHOOL, THIS SCENE IN THE UNITY NODE WOULD BE OF THE TEACHERS' LOUNGE. SIX EXPEDITION 35 CREW MEMBERS, INCLUDING HADFIELD (FAR RIGHT) TAKE A BRIEF MOMENT TO "LOUNGE"

ABOVE ANOTHER WAY TO CREATE NORMALCY IN SPACE IS TO KEEP EATING; BUT BEWARE, DIGESTION CAN TAKE SOME TIME TO MASTER PROPERLY

long duration space flight on human bodies, announcing in February 2014 that they will be sending two crew members to the space station on a one-year mission starting in late 2015. The data that they collect will help the next generation of space exploration.

"This will build on the rich experience of long-duration flights, including four flights of a year or more conducted by our Russian colleagues on the Mir station," explains Dr Michael Barratt, program manager for NASA's Human Research Program. "We have progressed considerably in our understanding of the human physiology in space and in countermeasures to preserve bone, muscle and fitness since then."

MORE THAN A TIN CAN

Along with regularly having to unblock the toilet and perform other maintenance activities, each day's work for ISS astronauts involves acting as human guinea pigs — conducting scientific experiments for a range of government agencies, businesses and non-profits. The results of their efforts have in turn made a very real difference to people's lives back on Earth.

Due to the fact that virulence and antibiotic resistance of microbial life forms increases in space (because microgravity appears to alter the way genes are expressed), the ISS is the perfect place to trial new approaches to creating vaccines. New treatments ▸

SPACE BY NUMBERS

US$100 BILLION

AT A COST OF ROUGHLY US$100 BILLION, THE ISS IS THE MOST EXPENSIVE SINGLE OBJECT EVER BUILT. FOR REFERENCE, THE LARGE HADRON COLLIDER COST SLIGHTLY MORE THAN US$6 BILLION

16X

OVER 16 TIMES AS MANY PEOPLE HAVE SUMMITED MOUNT EVEREST THAN HAVE BEEN TO THE ISS (3,500 PEOPLE COMPARED TO SOME 211)

3 GREAT SONGS

RATHER THAN AN ALARM CLOCK, THE CREW IS WOKEN BY A DIFFERENT SONG EACH MORNING, OFTEN CHOSEN BY A LOVED ONE DOWN ON EARTH. SONGS HAVE INCLUDED *MACHO MAN* BY THE VILLAGE PEOPLE, THE THEME TUNE FROM *WALLACE AND GROMIT*, AND MUSE'S *SUPERMASSIVE BLACK HOLE*.

10,000:1

IT COSTS US$10,000 FOR EVERY POUND OF PAYLOAD SENT INTO ORBIT

45 MINUTES

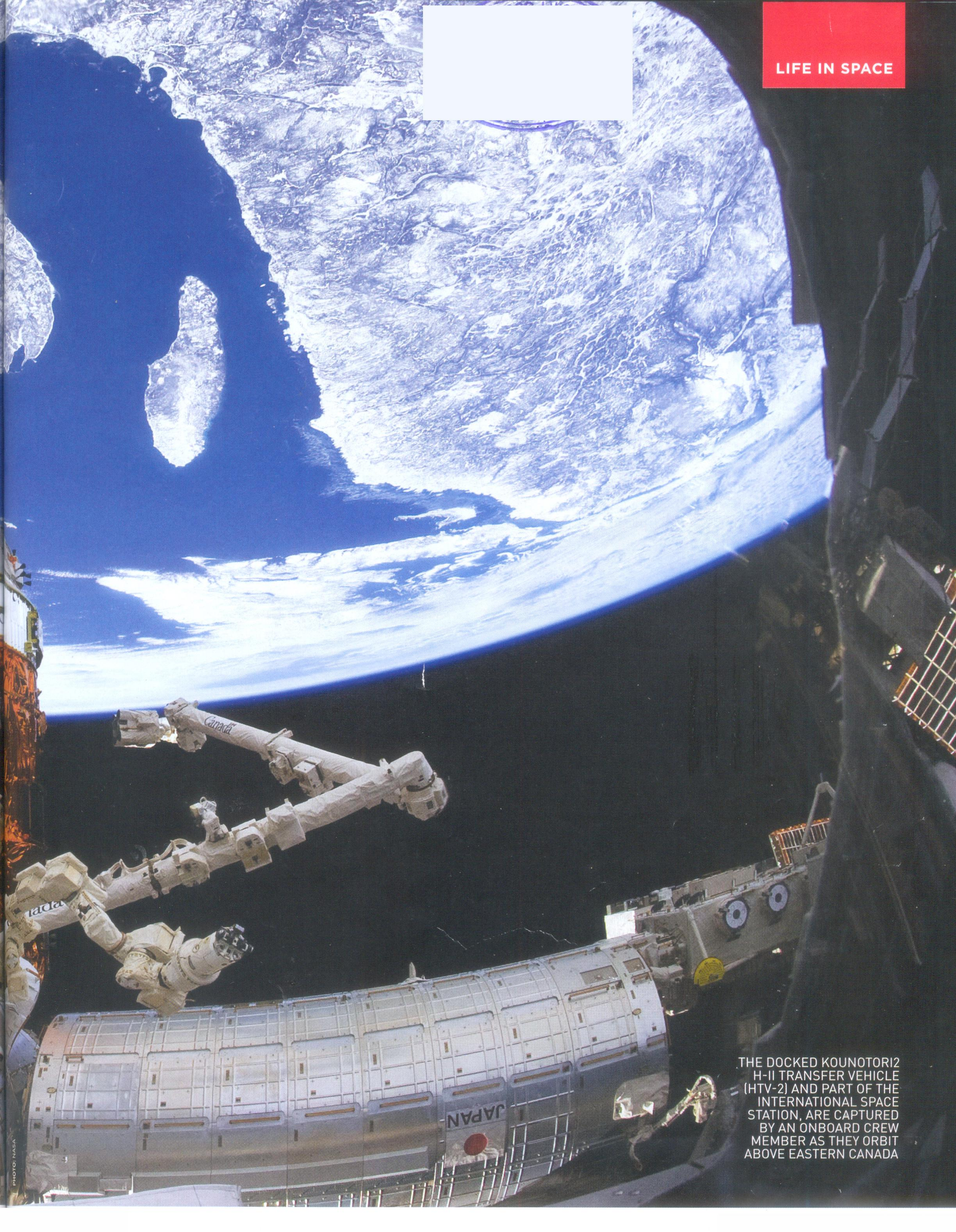
TIME IT TAKES JUST TO PUT ON THE SPACESUIT THAT ALLOWS AN ASTRONAUT TO EXIT THE ISS AND PERFORM A SPACEWALK OUTSIDE THE CRAFT, ALSO KNOWN AS EVA (EXTRAVEHICULAR ACTIVITY). TO ADAPT TO THE LOWER PRESSURE MAINTAINED IN THE SUIT, AN ASTRONAUT MUST ALSO SPEND OVER AN HOUR BREATHING PURE OXYGEN. WANT TO TALK LIKE ONE OF THE PROS? PUTTING THE SUIT ON IS CALLED "DONNING", WHILE REMOVING IT IS CALLED "DOFFING".

8:56

THE RECORD FOR LONGEST EVA WAS SNAGGED IN 2001, BY NASA ASTRONAUTS SUSAN J. HELMS AND JAMES S. VOSS, WHO TODDLED AROUND SPACE FOR EIGHT HOURS AND 56 MINUTES.

1969

A STUDY FROM THE UNIVERSITY OF BERKLEY CALLED "INTESTINAL HYDROGEN AND METHANE OF MEN FED SPACE DIET" WAS RELEASED IN '69. DURING NASA'S *GEMINI PROGRAMME*, ASTRONAUTS WHO ATE FOOD PREPARED FOR THAT MISSION PASSED FAR MORE GAS THAN THOSE WHO ATE BLAND FOOD. THE FEAR WAS THAT METHANE, A FLAMMABLE GAS THAT MAKES UP FARTS, MIGHT BUILD UP IN THE CONTROLLED ENVIRONMENT AND HEIGHTEN THE RISK OF FIRE. SILENT BUT DEADLY, INDEED.



THE DOCKED KOUNOTORI2 H-II TRANSFER VEHICLE (HTV-2) AND PART OF THE INTERNATIONAL SPACE STATION, ARE CAPTURED BY AN ONBOARD CREW MEMBER AS THEY ORBIT ABOVE EASTERN CANADA

PHOTO: NASA

▸ for prostate cancer use microencapsulation technology tested on the station; while ISS-grown, high quality protein crystals have been demonstrated to combat diseases such as muscular dystrophy. Climate change, disaster monitoring and urban growth on Earth are also monitored from the station, which performs a lap of our planet every 90 minutes.

Balance studies done on astronauts are being used to help predict the risk of falls in the elderly, while the technology behind the Canadian robotic arm, known as Canadarm, that first helped assemble and now services and maintains the station is being used to perform robotic surgery with pinpoint accuracy.

> "LIFE ON THE ISS HAS A MISREPRESENTED AIR OF TRANQUILLITY," SAYS HADFIELD. **"WITH 200 ONGOING EXPERIMENTS AND SIX MISSION CONTROLS IN CONSTANT CONTACT, IT'S A BUSY PLACE".**

Put simply, while life may appear calm and carefree, it is definitely busy up there. "Life on the ISS has a misrepresented air of tranquillity," says Hadfield. "With 200 ongoing experiments and six mission controls in constant contact, it's a busy place."

It is also about to become the coldest place in the universe. An 'atomic refrigerator' which is set for launch in 2016 will cool an area of the ISS to one ten billionth of a degree above absolute zero. All the thermal activity of atoms theoretically stops, while our concepts of solid, liquid and gas become irrelevant. Researchers hope that the super-chilled experiment will deliver us new insights into quantum theory, amongst others.

Another planned addition to the ISS program is a Lightning Imaging Sensor (LIS), which will detect and locate lightning above the tropics. Scheduled to launch in February 2016, the LIS hardware will look farther towards Earth's poles than existing sensors, and supply real-time information over data-sparse regions, such as oceans, to support weather forecasting and warning systems.

EXPECT THE UNEXPECTED

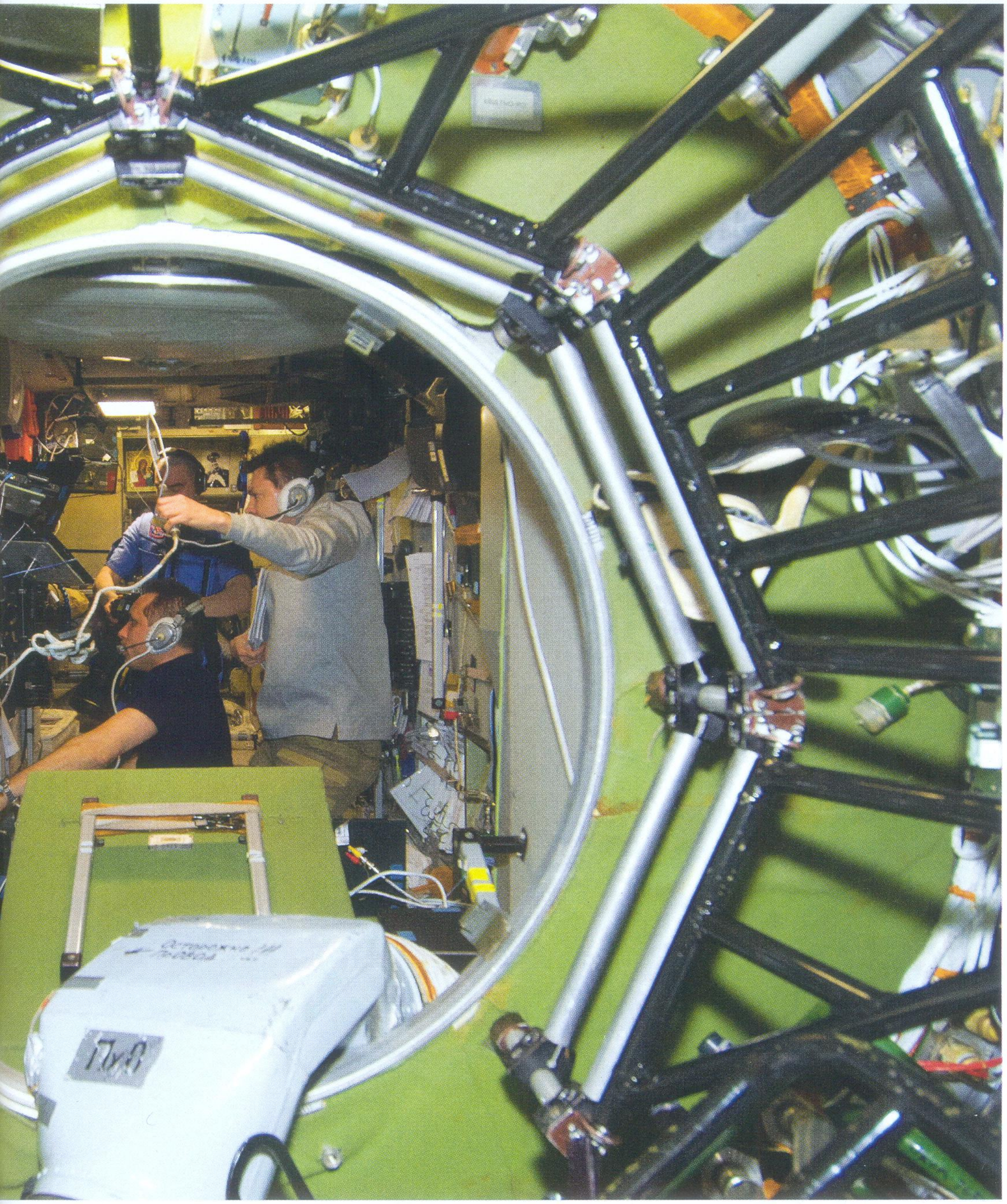
While Hadfield is one of the lucky few human beings to have spent time in space, he emphasises that he was just one part of a very large team of equally committed colleagues, both in space and on the ground; people who work, train, travel and socialise together for years. The ongoing bonding process also means that when the unexpected occurs, everyone comes together as one to deal with any problems.

"It's really important, because when dealing with something as complex and uncertain as leaving Earth, you don't want there to be any mistakes," he says.

Even during incidents such as Italian astronaut Luca Parmitano's helmet flooding during a space walk in July 2013, nearly drowning him, the response of other astronauts — and the support team at Mission Control — was not one of shock, but

ISS, EXPUNGE

The manifold successes and insights provided by the ISS program have resulted in several extensions to its life, which has now been extended until 2024. However, like the rubbish that is regularly jettisoned from the station to burn up spectacularly on re-entry to the Earth's atmosphere, eventually the ISS will outlive its usefulness and come to a fiery end. The parts that are too big to burn up will most likely splash down somewhere in the South Pacific, marking the most expensive act of deliberate destruction in human history.



rather, how could this be fixed and made right. NASA has since decided to equip its helmets with snorkels, should a similar cooling system malfunction occur again.

EXPERIMENTS SUCH AS ISS-GROWN HIGH QUALITY PROTEIN CRYSTALS HAVE BEEN DEMONSTRATED TO COMBAT DISEASES SUCH AS MUSCULAR DYSTROPHY.

"You don't want a shocked astronaut onboard," Hadfield laughs. The astronaut feels that the Oscar-winning film Gravity, starring Sandra Bullock and George Clooney, strayed most into fiction in the moments when the astronauts were portrayed as being overwhelmed by their situation, compounding the disaster that befell them. Instead, space training teaches you to stay in the zone, despite the obstacles. "I've been on three flights, with three different crews, and there has never been an emotional blowup," he says. "Plenty of debate and discussion, yes, but all based on rational content and developing solutions."

Travelling off the planet with other people also leaves you with a new understanding of teamwork, he says. "The key to a successful team is for each member to have a deep reserve of capability," says Hadfield. "And to be able to put others' concerns ahead of your own." It is advice, learned while floating in space, that he feels applies equally to life on Earth. ●

ABOVE "FOR ME, EVERYTHING PALES COMPARED WITH FLOATING WEIGHTLESS IN THE UNIVERSE" SAYS HADFIELD.

RIGHT LIFE ON THE ISS DOES TAKE SOME GETTING USED TO, FOR EXAMPLE THE LACK OF INSECTS ROAMING FREE

LEFT THE INCREDIBLE VIEWS AT ALL TIMES OF THE DAY AND NIGHT, SUCH AS SOUTH KOREA ALL LIT UP

PHOTOS: NASA; SPL/CLICK PHOTOS (TARDIGRADE)